UDK 582.542.11:581.192

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INVESTIGATION OF BENTGRASS (*AGROSTIS* L.) IN M.M. GRYSHKO NATIONAL BOTANICAL GARDEN OF THE NAS OF UKRAINE

Objective *— to establish biological and biochemical properties of plants of the genus Agrostis L. species in conditions of M.M. Gryshko National Botanical Garden of the NAS of Ukraine.*

Material and methods. *The objects of these investigations were species and cultivars of the genus Agrostis species. It was conducted morphometric measurements and some parameters of the productivity in the flowering stage. The content of dry matter and fats were determined according to A.I. Yermakov, the total content of sugars and ascorbic acid concentration — according to V.P. Krishchenko, the content of carotene — according to B.P. Pleshkov, the content of ash — according to Z.M. Hrycajenko et al., the content of calcium and phosphorus — according to H.N. Pochinok.*

Results. *The vegetation period of investigated plants varied from 245.0 to 252.5 days. The morphometric parameters in the flowering stage were: the height of plants from 33.3 to 54.91 cm, the diameter of the stem — from 0.90 to 1.47 mm, the number of internodes — from 1.80 to 3.20, number of leaves — from 2.00 to 3.80, the length of inflorescence — from 6.80 to 17.00 cm, the width of inflorescence — from 1.55 to 6.85. The content of dry matter during vegetation was from 28.62 to 48.58 %, the total content of sugars — from 6.66 to 19.96 %, ascorbic acid — from 19.47 to 181.43 mg%, carotene — from 0.42 to 6.05 mg%, ash — from 3.93 to 10.23 %, calcium — from 0.32 to 0.98 %, phosphorus — from 0.03 to 0.22 %, fats — from 0.40 to 4.45 %.*

Conclusions*. These investigations have shown that in M.M. Gryshko National Botanical Garden of the NAS of Ukraine conditions the plants of the genus Agrostis have a long-term vegetative period (more than 8 months). The raw material of investigated plants is a valuable source of nutrients. The most content of them was noticed in the tillering period. The maximal amount of total sugars accumulates during the flowering stage.*

Key words: *Agrostis* L., morphometric parameters, biochemical characteristic.

Due to the extensive use of wild plants in agriculture, the number of cultivated crops has increased. New introduced plants have many important biological values such as high productivity, high content of protein in biomass, etc. Most of them give high biomass during ten years and more.

The grass family (*Poaceae*) is undoubtedly one of the most important plants to humankind, agriculturally, economically and ecologically. It provides the major cereal crops and most of the grazing for wild and domestic herbivores. Grasslands are estimated to comprise about 20% of the world's vegetation. *Poaceae* is also one of the largest families of flowering plants with more than 650 genera and about 10,000 species [3, 11]. One of the most interesting plants of *Poaceae* is the genus of *Agrostis* L. represented by 9 species in Ukrainian flora [8].

Previous investigations of *Agrostis* species showed that these plants are objects of numerous studies such as morphological, anatomical, genetical, ecological, physiological, microbiological, and agronomical [12—14, 17, 18, 21, 23, 24, 28, 33]. The plant's raw material is rich in amino acids [31]. Some studies have focused on tolerance of *Agrostis* species to the accumulation of heavy metals [22]. The tested leaf tissues of *A. palustris* showed that plants can be model samples for the investigation of the water stress effect and some plant tolerance [30]. Some results suggest that specific groups of signaling molecules may induce tolerance of *A. stolonifera* to heat stress by reducing oxidative damage [25, 27]. Study of cell selection reported that *A. stolonifera* plants can be used for cultivation under soil salinity [1]. Significant relationships were found between normalised difference vegetation indices and pigment status of *A. stolonifera* plants that connected with potential influence turf

reflectance [32]. As a result of studying the growth and development of *A. stolonifera*, it is revealed that this plant is a good soil retarder with active vegetative development [4]. The using of these plants in agriculture as crops increases the total nutritional value of forage and thereby improves on the quality of milk of farm animals [19, 20]. Despite the obtained data, the investigation of the raw of the *Agrostis* species is actually nowadays.

Material and methods

Plant material was collected in M.M. Gryshko National Botanical Garden of the NAS of Ukraine. The species, cultivars and one variety of *Agrostis* were used to investigate: *A. capillaris* L. (AC), *A. stolonifera* L. (AS), *A. stolonifera* L. cv. Klonova (ASK), *A. stolonifera* var. trinerrata (Maire & Trab.) Maire & Weiller (ASTR), *S. tenerrima* Trin. (AT), *S. tenerrima* Trin. cv. Desnianska 51 (ATD). The measurements of morphometric parameters of investigated plants done in stage of flowering. Plant height was measured dynamically with the aim to determine the plant growth depending on a period of germination. All biochemical analyses were conducted using the above-ground part of plants during vegetation. The determination of absolutely dry matter done by drying to constant weight at 100—105 °C according to A.I. Yermakov [7]. The total content of sugars was investigated by Bertrand method in water extracts. The concentration of ascorbic acid (AA) of the acid extracts determined by a 2.6-dichlorophenol-indophenol method that based on the reduction properties of AA. Both analyses carried out according to V.P. Krishchenko [6]. The concentration of total carotene determined according to B.P. Pleshkov. Procedure carried out in petrol extracts by spectrophotometric method using 2800 UV/VIS Spectrophotometer, Unico. Mixtures were left in a shaker for 2 hours and their absorbance was measured at the wavelength of 440 nm [9]. The level of total ash was determined using the method of combustion in muffle-oven (SNOL 7.2-1100, Termolab) at 300—800 °C until the samples turned into white ash to constant weight according to Z.M. Hrycajenko et al. [2]. The concentration of calcium was determined by titration method of acid extracts with Trilon B. Phosphorus content in plants was identified in acid extracts using molybdenum solution. Both these analyses done according H.N. Pochinok [10]. The procedure of the determination of total oil level was performed using Soxhlet extractor with petroleum ether [7]. Experimental data were evaluated by using Excel 2010.

Results and discussions

Department of the Cultural flora of National Botanical Garden of the NAS of Ukraine has the collection of the lawn grass which has 2 species and 3 cultivars of *Agrostis* [5]. A long-term investigation of these plants has estimated that period of vegetation starts from the second decade of March and continues until snowfall period. The duration of the growing season was from 245.0±10.0 (AST) to 252.5 ± 8.0 (ATD) days. The middle means of high of *Agrostis* species and cultivars are showed in the table (Tabl. 1).

The height of investigated plants in a stage of the tillering was from 16.02 to 27.70, the paniculation — from 22.89 to 41.30, the flowering — from 41.77 to 52.80 cm. In total, coefficient of variation wasn't significant (from 0.95 to 4.54 %).

The total height accretion of plants from the tillering to the flowering stage was 19.26 (AS), 21.06 (AT), 26.35 (ASK) and 31.71 cm (ATD). Our observations noticed that plants AT had a minimal intensity of plant growth (2.92 cm) and plants ATD — maximum intensity of plant growth (20.21 cm) in period tillering — paniculation.

In the flowering stage the highest generative stems, length and width of inflorescence and the greatest diameter of stem were 54.91, 17.00 and 6.85 cm, 1.47 mm respectively (ATD). The greatest number of internodes and number of leaves were 3.20 and 3.80 respectively (AT) and the greatest length of stolon — 27.70 cm (ASK) (Tabl. 2).

The lowest height of generative stem and width of inflorescence were 33.31 cm and 1.55 cm respectively (ASTR), stem diameter and length of inflorescence were 0.90 mm and 6.80 cm respectively (ASK), number of internodes and length of stolon were 1.80 and 17.25 cm respectively (AS), number of leaves on stem was 2.00 (ATD). It was noticed that plants of AT and ATD don't have stolons.

Table 1. **Dynamic of height of plants of the genus *Agrostis* L. during vegetation**

Growth stage	Sample	Min	Max	m	σ	V, %
Tillering	AS	21.2	23.5	22.51	0.71	3.14
	ASK	15.7	16.3	16.02	0.19	1.17
	AT	27.0	28.3	27.70	0.43	1.54
	ATD	20.0	22.8	21.09	0.96	4.54
Paniculation	AS	28.7	31.2	29.60	0.80	2.71
	ASK	22.1	24.0	22.89	0.54	2.36
	AT	29.0	33.0	30.62	1.33	4.34
	ATD	40.0	43.0	41.30	1.13	2.73
Flowering	AS	40.5	43.1	41.77	0.86	2.05
	ASK	41.0	44.0	42.37	0.97	2.29
	AT	48.0	49.3	48.76	0.46	0.95
	ATD	50.2	55.0	52.80	1.61	3.04

Table 2. **Morphometric parameters of plants of the genus *Agrostis* L. in the flowering stage**

Parameter	AS	ASK	AT	ATD	ASTR
Height of generative stem, cm	41.4 ± 2.75	43.20 ± 3.90	48.52 ± 3.48	54.91 ± 2.86	33.31 ± 2.43
Diameter of stem, mm	1.18 ± 0.11	0.90 ± 0.04	1.10 ± 0.08	1.47 ± 0.11	1.00 ± 0.17
Number of internodes	1.80 ± 0.28	1.90 ± 0.10	3.20 ± 0.35	1.93 ± 0.14	2.32 ± 0.21
Number of leaves on stem	2.30 ± 0.42	2.20 ± 0.18	3.80 ± 0.46	2.00 ± 0.00	2.50 ± 0.23
Length of inflorescence, cm	14.33 ± 1.08	6.80 ± 0.48	16.05 ± 1.01	17.00 ± 0.89	7.63 ± 0.56
Width of inflorescence, cm	4.75 ± 0.74	2.50 ± 0.00	4.95 ± 0.31	6.85 ± 0.76	1.55 ± 0.13
Length of stolon, cm	17.25 ± 1.01	27.70 ± 12.5	Stolons are absent	Stolons are absent	18.92 ± 2.41

Table 3. **Number of vegetative and generative stems of plants of the genus *Agrostis* L. (per 1 dm^2)**

Sample	Number of generative stems				
	Min	Max	m	σ	V, %
AS	27	112	69.9	29.79	42.62
ASK	22	86	50.9	23.62	46.40
ASTR	135	211	171.7	27.50	15.87
AT	60	74	68.4	4.81	7.04
ATD	14	75	47.9	24.21	50.55
Sample	Number of vegetative stems				
	Min	Max	m	σ	V, %
AS	57	82	69.1	8.81	12.75
ASK	37	61	48.3	7.90	16.36
ASTR	70	103	88.1	11.07	12.57
AT	14	40	24.9	9.23	37.07
ATD	13	57	36.9	16.23	43.99

It is very difficult to determine some parameters of productivity of these plants quaintly because of growth density. We also took into account this fact and the number of stems was calculated per dm^2. It was found that a number of generative stems was from 47.9 to 171.7 and vegetative — from 24.9 to 88.1 (Tabl. 3).

The accumulation of biochemical compounds is a very important complex of parameters that can show life strategies of these or other species of plants. Results of the biochemical study can be helpful for the recommendation and use plants in the national economic. The most widespread nutrients in the crop are vitamins, ash and it mineral complex, dry matter, fats. The biochemical analyses were carried out to estimated value of the raw material of plants of the genus *Agrostis*. As resulted by Sidhu et al. (2013) the thatch layer of *A. stolonifera* showed the high content of sugars, total organic and lignin content [26]. According to the results of the biochemical research was noted the highest content of dry matter and calcium in tillering period in plants of ASTR (37.38 and 0.98 % respectively), the total content of sugars — in the plants of AT (14.06 %), ascorbic acid — in the plants of ATD (181.43 mg%), carotene, ash, phosphorus and level of fats — in the plants of AS (6.05 mg%, 10.23, 0.22 and 4.45 % respectively) (Tabl. 4). It was noted in a period of tillering the accumulation of ascorbic acid was maximal. This vitamin is very important like a protector in the plant tissues [16].

The lowest content of dry matter and level of fats was noted in plants of AT (28.62 and 2.21 % respectively), the lowest total content of sugars and ascorbic acid — in plants of AC (6.66 % and 36.29 mg%), the carotene and ash content — in plants of ASTR (2.26 mg% and 5.24 % respectively), calcium — in plants of AS (0.32 %).

The content of ascorbic acid of AT was 2.7 times less than cultivar sample. The same consistent pattern was noted to AS and it cultivar ASK. The concentration of ascorbic acid 4.0 times less in ASK.

Table 4. **Biochemical characteristic of plants of the genus *Agrostis* L. in the tillering stage**

Parameter	AC	AS	ASK	ASTR	AT	ATD
Dry matter, %	30.81 ± 0.14	29.88 ± 0.45	28.88 ± 0.19	37.38 ± 0.42	28.62 ± 0.27	28.79 ± 0.64
Sugars, %	6.66 ± 0.50	7.41 ± 0.20	12.98 ± 0.39	9.49 ± 0.26	14.06 ± 0.41	8.06 ± 0.27
Ascorbic acid, mg%	36.29 ± 0.59	44.47 ± 0.81	180.91 ± 5.50	41.58 ± 2.45	67.26 ± 2.77	181.43 ± 5.51
Carotene, mg%	4.88 ± 0.01	6.05 ± 0.03	5.42 ± 0.01	2.26 ± 0.01	5.71 ± 0.01	6.04 ± 0.01
Ash, %	9.25 ± 0.13	10.23 ± 0.28	8.16 ± 0.09	5.24 ± 0.19	6.84 ± 0.13	7.67 ± 0.01
Calcium, %	0.42 ± 0.01	0.32 ± 0.01	0.43 ± 0.01	0.98 ± 0.03	0.46 ± 0.01	0,36 ± 0.01
Phosphorus, %	0.12 ± 0.01	0.22 ± 0.01	0.12 ± 0.01	0.03 ± 0.00	0.11 ± 0.01	0.11 ± 0.01
Fats, %	3.41 ± 0.22	4.45 ± 0.22	3.19 ± 0.41	2.34 ± 0.16	2.21 ± 0.16	3.07 ± 0.11

Table 5. **Biochemical characteristic of plants of the genus *Agrostis* L. in the paniculation stage**

Parameter	AS	ASK	ASTR	AT	ATD
Dry matter, %	32.22 ± 0.13	37.66 ± 0.32	34.16 ± 0.09	30.85 ± 0.06	36.58 ± 0.33
Sugars, %	8.89 ± 0.88	11.58 ± 0.13	7.85 ± 0.06	9.99 ± 0.12	7.19 ± 0.39
Ascorbic acid, mg%	102.41 ± 4.93	19.47 ± 2.43	46.70 ± 1.17	47.54 ± 2.97	42.99 ± 2.53
Carotene, mg%	2.32 ± 0.02	2.35 ± 0.01	0.96 ± 0.01	4.06 ± 0.04	4.27 ± 0.02
Ash, %	5.72 ± 0.06	5.69 ± 0.22	4.10 ± 0.09	5.68 ± 0.18	3.93 ± 0.02
Calcium, %	0.84 ± 0.10	0.54 ± 0.01	0.43 ± 0.02	0.67 ± 0.04	0.84 ± 0.02
Phosphorus, %	0.03 ± 0.00	0.03 ± 0.00	0.12 ± 0.00	0.11 ± 0.01	0.08 ± 0.00
Fats, %	1.81 ± 0.09	2.94 ± 0.07	2.09 ± 0.19	0.97 ± 0.11	3.16 ± 0.05

Table 6. **Biochemical characteristic of plants of the genus *Agrostis* L. in the flowering stage**

Parameter	AC	AS	ASK	ASTR	AT	ATD
Dry matter, %	48.58 ± 0.03	41.20 ± 0.13	35.12 ± 0.01	42.34 ± 0.20	44.78 ± 0.14	37.30 ± 0.03
Sugars, %	14.76 ± 0.31	8.03 ± 0.05	19.96 ± 0.23	18.67 ± 0.25	8.09 ± 0.04	9.85 ± 0.09
Ascorbic acid, mg%	27.45 ± 1.72	50.49 ± 1.66	52.32 ± 1.23	47.25 ± 3.41	54.98 ± 3.56	50.27 ± 2.32
Carotene, mg%	1.56 ± 0.01	0.55 ± 0.01	0.40 ± 0.02	0.95 ± 0.01	0.42 ± 0.03	0.78 ± 0.01
Ash, %	5.46 ± 0.27	4.16 ± 0.12	5.75 ± 0.38	5.74 ± 0.23	4.79 ± 0.36	4.18 ± 0.37
Calcium, %	0.70 ± 0.01	0.32 ± 0.01	0.60 ± 0.04	0.54 ± 0.01	0.67 ± 0.04	0.65 ± 0.01
Phosphorus, %	0.07 ± 0.00	0.14 ± 0.00	0.12 ± 0.00	0.08 ± 0.00	0.11 ± 0.01	0.12 ± 0.00
Fats, %	1.87 ± 0.23	0.95 ± 002	0.40 ± 0.06	2.19 ± 0.02	0.97 ± 0.11	1.10 ± 0.01

Both plant raw materials — ASK and ATD accumulated ascorbic acid more than 180 mg%. It should be noted that investigated plants accumulated the high content of total carotene. In the tillering period, its content was from 2.26 to 6.05 mg% depending on samples. The data obtained by Atkeson et al. (1937) showed that certain pasture grasses of cereals have a high content of carotene from 17.2 to 57.2 mg% on the fresh basis [15]. McElroy et al. (2009) reported in the review about a concentration of carotene in *Agrostis palustris* from 4.1 to 7.0 mg% (per dry mass) [29]. This is similar to our results.

In the next period of plant growing the greatest content of dry matter, total content of sugars and fat level were discovered in the over-ground part of plants of ASK (37.66, 11.58 and 2.94 % respectively), ascorbic acid, ash and calcium — in plants of AS (102.41 mg%, 5.72 and 0.84 % respectively), carotene — in plants of ATD (4.72 mg%), phosphorus — in plants of ASTR (Tabl. 5). As can be seen from the table data the both — AS and ATD plants had the same level of calcium (0.84 %). The lowest content of dry matter and fat level in the period of paniculation were in the over-ground part of AT (30.85 and 0.97 % respectively), total content of sugars and ash — in the over-ground part of plants of ATD (7.19 and 3.93 %), ascorbic acid and phosphorus — in plants of ASK (19.47 mg% and 0.03 %), carotene and calcium — in plants of ASTR (0.96 mg% and 0.43 %).

In the flowering stage the highest content of dry matter, calcium and carotene were obtained in the raw material of AC (48.58, 0.70 % and 1.56 mg% respectively), phosphorus — in the raw material of AS (0.14 %), total content of sugars and ash — in the raw material of ASK (19.96 and 5.75 % respectively), fat level — in the raw material of ASTR (2.19 %), ascorbic acid — in the raw material of AT (54.98 mg%) (Tabl. 6).

The lowest content of dry matter, fat level and the carotene in the flowering stage of *Agrostis* were obtained in plants of ASK (35.12, 0.40 % and 0.40 mg% respectively); total content of sugars, ash and calcium — in samples of AS (8.03, 4.16 and 0.32 % respectively); ascorbic acid and phosphorus — in samples of AC (27.45 mg% and 0.07 %).

Conclusions

This research was demonstrated basic biological aspects of further usage of *Agrostis* species not only as a lawn grass. The raw material of *Agrostis* is a reliable source of carotene (AS, ATD), ascorbic acid (ATD), dry matter (ASTR), macroelements (ASTR, AS) and fats (AS) as a fodder in the tillering period. Moreover, the level of sugars increases to the flowering stage. The greatest height accretion of plants from the tillering to the flowering stage was noticed for ATD raw. Some morphometric parameters and number of vegetative and generative stems suggest the productive potential of these plants. The maximal quantity of vegetative and generative stems has produced plants of ASTR.

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Рекомендував П.Є. Булах
Надійшла 01.04.2017

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Recommended by P.E. Bulakh
Received 01.04.2017

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ДОСЛІДЖЕННЯ МІТЛИЦІ (*AGROSTIS* L.) У НАЦІОНАЛЬНОМУ БОТАНІЧНОМУ САДУ імені М.М. ГРИШКА НАН УКРАЇНИ

Мета роботи — встановити біологічні та біохімічні особливості рослин видів роду *Agrostis* L. в умовах Національного ботанічного саду імені М.М. Гришка НАН України.

Матеріал та методи. Об'єктами дослідження були види та сорти видів роду *Agrostis*. Морфометричні вимірювання та вивчення деяких параметрів продуктивності здійснювали в період цвітіння. Вміст сухої речовини і жирів визначали за А.І. Єрмаковим, загальний вміст цукрів та концентрацію аскорбінової кислоти — за В.П. Крищенком, вміст каротину — за Б.П. Плєшковим, вміст золи — за З.М. Грицаєнко та ін., вміст кальцію та фосфору — за Х.Н Починком.

Результати. Період вегетації у досліджуваних рослин становив від 245,0 до 252,5 доби. Встановлено морфометричні параметри в період цвітіння: висота рослин — від 33,31 до 54,91 см, діаметр стебла — від 0,90 до 1,47 мм, кількість міжвузлів — від 1,80 до 3,20, кількість листків — від 2,00 до 3,80, довжина суцвіття — від 6,80 до 17,00 см, ширина суцвіття — від 1,55 до 6,8 см. Вміст сухої речовини протягом вегетації становив від 28,62 до 48,58 %, загальний вміст цукрів — від 6,66 до 19,96 %, аскорбінової кислоти — від 19,47 до 181,43 мг%, каротину — від 0,42 до 6,05 мг%, золи — від 3,93 до 10,23 %, кальцію — від 0,32 до 0,98 %, фосфору — від 0,03 до 0,22 %, жирів — від 0,40 до 4,45 %.

Висновки. В умовах Національного ботанічного саду імені М.М. Гришка НАН України рослини видів роду *Agrostis* L. характеризуються тривалим періодом вегетації (понад 8 міс.). Рослинна сировина досліджуваних рослин є цінним джерелом поживних речовин. Найбільший вміст їх зафіксовано в період кущіння. Максимальна кількість суми цукрів накопичується в період цвітіння.

Ключові слова: *Agrostis* L., морфометричні параметри, біохімічні характеристики.

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ИССЛЕДОВАНИЕ ПОЛЕВИЦЫ (*AGROSTIS* L.) В НАЦИОНАЛЬНОМ БОТАНИЧЕСКОМ САДУ ИМЕНИ Н.Н. ГРИШКО НАН УКРАИНЫ

Цель работы — установить биологические и биохимические особенности растений видов рода *Agrostis* L. в условиях Национального ботанического сада имени Н.Н. Гришко НАН Украины.

Материал и методы. Объектами исследования были виды и сорта видов рода *Agrostis*. Морфометрические измерения и изучение некоторых параметров продуктивности осуществляли в период цветения. Содержание сухого вещества и жиров определяли по А.И. Ермакову, общее содержание сахаров и концентрацию аскорбиновой кислоты — по В.П. Крищенко, содержание каротина — по Б.П. Плешкову, содержание золы — по З.М. Грицаенко и др., содержание кальция и фосфора — по Х.Н. Починку.

Результаты. Период вегетации у исследуемых растений составлял от 245,0 до 252,5 суток. Установлены морфометрические параметры в период цветения: высота растений — от 33,3 до 54,91 см, диаметр стебля — от 0,90 до 1,47 мм, количество междоузлий — от 1,80 до 3,20, количество листьев — от 2,00 до 3,80, длина соцветия — от 6,80 до 17,00 см, ширина соцветия — от 1,55 до 6,85 см. Содержание сухого вещества на протяжении вегетации составляло от 28,62 до 48,58 %, общее содержание сахаров — от 6,66 до 19,96 %, аскорбиновой кислоты — от 19,47 до 181,43 мг%, каротина — от 0,42 до 6,05 мг%, золы — от 3,93 до 10,23 %, кальция — от 0,32 до 0,98 %, фосфора — от 0,03 до 0,22 %, жиров — от 0,40 до 4,45 %.

Выводы. В условиях Национального ботанического сада имени Н.Н. Гришко НАН Украины растения видов рода *Agrostis* характеризуются продолжительным вегетационным периодом (более 8 мес.). Растительное сырье исследуемых растений является ценным источником питательных веществ. Наибольшее содержание их зафиксировано в период кущения. Максимальное количество суммы сахаров накапливается в период цветения.

Ключевые слова: *Agrostis* L., морфометрические параметры, биохимические характеристики